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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : B27N 5/00

A1

(11) International Publication Number: WO 91/12944

(43) International Publication Date: 5 September 1991 (05.09.91)

(21) International Application Number: PCT/US91/01182

(22) International Filing Date: 22 February 1991 (22.02.91)

(30) Priority data:
485,434 23 February 1990 (23.02.90) US

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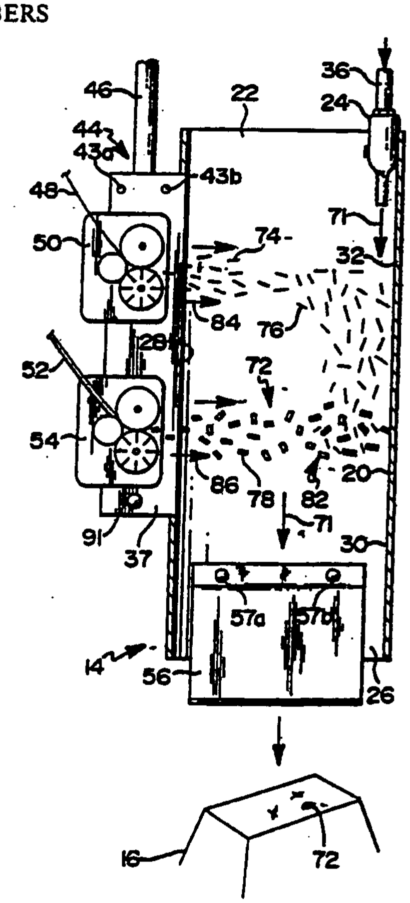
(81) Designated States: AT (European patent), BE (European patent), CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent).

Published
With international search report.

(54) Title: APPARATUS AND METHOD FOR APPLYING PREFORM FIBERS

(57) Abstract

A method and apparatus (10) for applying preform fibers (72) to foraminous molds (16) using strands of binder (48) and glass fibers is disclosed. A strand of binder fiber is chopped and entrained into a chute (20). The chute has a longitudinal airstream (71) directed therethrough toward the foraminous mold. The binder fiber (74) is separated into filaments (76) by the airstream. The glass fiber strand (52) is chopped and entrained into the chute downstream of the filaments. The chopped glass (78) and the binder filaments mix within the chute and are then directed by the airstream onto the preform mold. The mixture may be fanned out from the chute to provide more even coverage of large sized molds.



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APPARATUS AND METHOD FOR APPLYING PREFORM FIBERS

BACKGROUND OF THE INVENTION

Field of the Invention:

The present invention relates generally to the manufacture of directed-fiber preforms. More specifically, the present invention relates to an apparatus and method for applying the fibers making up the preform onto a foraminous mold.

Description of the Related Art:

Directed-fiber preforms are a well known commodity used in the making of various finished products. These preforms are made by forming a substantially open, three dimensional matrix of structural fibers and water based binder into a shape resembling the finished product. The structural fibers are commonly glass fibers. These glass fibers are bound together into the preform shape by the binder which is commonly a water borne adhesive material. The preform is then additionally processed, by applying heat to drive off the water and set the binder. The set preform is then soaked in resins, and subsequently finish molded into a final product.

One method and apparatus for making directed-fiber preforms using a horizontally translated shuttle is described in applicant's application Serial No. 07/413,463, filed September 27, 1989, which is herein incorporated by reference.

In a known method of making of directed-fiber preforms illustrated in Reinforcement Digest pg. 18, Vol. 46, Jan. 1989; glass fiber roving is chopped to short fiber lengths by an electrically powered chopping apparatus. The glass fiber is then fed through a hopper to a venturi in a tube connected at one end to a high powered fan. A spray head is suspended at the opposite, opened end of the tube for directing a binder liquid. The apparatus directs the

glass fibers and binder liquid onto a rotating foraminous mold, or screen, in the shape of the preform to be made. Because the gun is fixed, rotation of the mold is required to cover the mold with fibers. A partial vacuum located behind the mold holds the fibers in place on the mold. The preform is then heated to drive off the water of the binder and activate the binder to set the glass into a matting.

This method results in large amounts of particulate emissions due to "splash-back" from the binder liquid/glass mixture hitting the rotating mold, resulting in material waste, operator health risks, and added labor expense in clean up. Contamination of the environment also results from a binder liquid which commonly contains isocyanates and/or formaldehydes which are released to the atmosphere upon drying and curing the preform.

Further, the preform manufacture process is slowed by the time needed to drive off the water from the binder in the wet preform, and is made more expensive by the heat required to do so.

Also, by using an aqueous binder, such as the commonly used latex slurry, the binder, when heated, will tend to fuse and run in the matrix of the preform. Thus, a webbing or lamination is formed in the matrix which blocks the efficient flow of resins therethrough in the subsequent finishing steps.

U.S. Patent No. 3,328,383 ('383) illustrates another method of applying fibers to preforms. The '383 patent discloses a substantially "dry" method of fiber deposition which forms frangible binder filaments from a resinous binder melt immediately prior to their mixing with the glass fibers. The glass fibers are cut from roving and the binder filaments are shattered when the glass and binder are simultaneously fed through a chopping mechanism from whence they are fed to a chamber having a mold therein. An

airstream is directed against the flow of fiber particles to distribute them throughout the chamber. The fibers are then deposited onto the foraminous mold.

In such a process many independent variables must be controlled to ensure the correct ratio of binder filament-to-glass fiber. For example, in such a system, diameter of the binder filaments is dependent upon the pressure applied to the resin melting tank, the heat of the melt tank, the diameter of the orifice plate holes which extrude the binder filament, and the pressure and rotation speed of the binder filament take up rollers. Further, the heavier glass fibers and lighter binder filaments may separate upon contact with the opposing airstream, causing an uneven distribution of binder fibers through the preform. The agglomerated binder fibers will then fuse and form globules upon curing, resulting in a weakened preform structure. Also, changeover of machine use from one type of binder filament to another is not quickly accomplished in the '383 apparatus.

There is, therefore, need for a preform fiber delivery device which minimizes wasted material, reduces environmental contamination, is fast and efficient, and is simple and reliable to use with a variety of different structural fiber and binder filament types. Further, this fiber delivery system should create a preform comprising an evenly distributed three dimensional matrix of randomly oriented preform fibers in which massing, or agglutination of binder material is minimized. The preform matrix created should further be able to be quickly and efficiently set. The present invention provides a device having the above-cited advantages over the prior art.

SUMMARY OF THE INVENTION

The present invention provides an apparatus for the delivery of fibers to a foraminous mold, comprising:

(a) a substantially tubular chute having:

(1) a first end having an opening for receiving an airstream,

(2) a second end having an opening for discharging preform fibers, and

(3) an opening in the chute for admitting preform fibers into the chute;

(b) means for attaching a binder fiber chopper in proximity to the chute;

(c) means for attaching a structural fiber chopper in proximity to the chute ;and,

(d) an air nozzle for directing an airstream through the chute in a direction from the first chute end to the second chute end.

Attached to the chute are binder fiber and structural fiber choppers, which serve to chop, or cut, the binder and structural fibers, which are supplied in strands. Once the preform fibers, i.e., binder and structural fibers, are cut into short lengths, the choppers also entrain the cut fibers into the chute.

The binder fiber chopper is located upstream on the chute. By "upstream" it is meant proximal to the chute first end, which is upstream on the longitudinal airstream supplied by the nozzle. As the cut binder fiber is entrained into the longitudinal airstream the binder fiber is separated into individual binder filaments. These individual binder filaments are carried downstream within the chute by the longitudinal air stream.

The structural fiber chopper is located downstream of the binder fiber chopper. The cut structural fiber lengths are entrained into the longitudinal airstream, which is carrying the binder filaments. Any residual clumps of binder filaments are separated into individual filaments upon collision with the heavier structural fiber lengths, which do not separate out into individual filaments. The mixture of binder filaments and structural

fiber lengths, i.e., preform fibers, is carried by the longitudinal airstream out the second end of the tube. The dispersal pattern of the preform fibers coming out of the chute may be modified at the chute second end by additional airstreams, or mechanical baffles, or like means, impinging upon the preform fiber mixture.

The preform fibers are then deposited upon a foraminous mold in an evenly distributed, three dimensional matrix of randomly oriented preform fibers. This matrix is then set into a preform by heat. In the matrix, the structural fiber lengths will be bound by numerous individual and separate binder filaments. Because the binder filaments do not agglomerate they will not run or form globules, i.e., agglutinate; in the matrix when heated, which would lead to a weakened preform structure and/or subsequent finishing problems, as previously said. Instead, the filaments stay elongated and bound to the structural fibers in a strong interlaced structure.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an environmental view of an apparatus embodying the present invention.

Figure 2 is a second environmental view.

Figure 3 is a front view of an apparatus embodying the present invention.

Figure 4 is a cross sectional view taken along line IV-IV of Figure 3 and disclosing operational details of the present invention.

Figure 5 is graphic aid to understanding fiber distribution.

Figure 6 illustrates in enlarged detail the various forms taken by the preform fibers as seen in Figure 4.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

As seen in Figure 1 a preform manufacture

apparatus 10 comprises a mold control apparatus 12 previously disclosed by the applicant in Serial No. 07/413,463, and a fiber delivery device 14. The mold control apparatus 12 horizontally translates a foraminous mold 16 over a vacuum source 18 during which the constituent fibers, i.e., the structural and binder fibers, of the preform are deposited on the mold 16.

The activation of the fiber delivery device 14 is controlled by a control unit 70 which controls the shuttle movement so as to activate the fiber delivery device 14 when the mold 16 is in the proper position to receive fiber from the delivery device 14.

As seen in Figures 3 and 4, the fiber delivery device 14 comprises a substantially tubular chute 20 made of steel or other suitably surface-hard material so as to withstand impingement thereon of glass fiber, or other preform structural fibers as may be found desirable to use, as further explained below.

The chute 20 has a substantially open first end 22 for receiving an airstream from a directed fluid source such as delivery nozzle 24, as further explained below. The chute has a substantially open second end 26, opposite the first open end 22, through which the preform fibers 72 exit the chute 20.

A side opening 28 is formed longitudinally in the chute 20 to allow the preform fibers 72 to be entrained into the interior of the chute 20. The side opening 28 does not run the entire longitudinal length of the chute 20 in the preferred embodiment, but stops short of the chute second end 26 to leave an enclosed cylindrical portion 30 of the chute 20 proximal to the chute second end 26 to provide a choke or other directing means on the dispersal of the filaments fibers as further explained below.

The airstream delivery nozzle 24 is preferably attached to a wall of the chute 20, proximal to the chute

first end 22. The nozzle 24 is positioned to provide a longitudinal airstream 71 through the chute 20 from first chute end 22 to second chute end 26. As shown, the nozzle 24 is affixed within the interior of the chute 20 to a chute wall 32 opposite the side opening 28 by means of a clamp 34 comprising a metal strap 33 fitted over the nozzle 24 and held by pop rivets 35a, 35b. Alternatively, the nozzle 24 may be affixed by adhesives, welding, etc. within or without the chute 20 so long as the proper airstream is achieved, as further explained below. The nozzle 24 receives pressurized air from an air line 36 attached to the nozzle 24 in the known manner, and conveying the pressurized air from a compressor (not shown) or the like.

A rectangular mounting plate 38, providing means for attaching first and second fiber choppers 40, 42 respectively, is affixed to the chute 20 by retaining a chute side flange 39 at one longitudinal side of the side opening 28, and positioning the side flange 39 between the mounting plate 38 and an opposing plate 37. The plates 37, 38 are attached to the side flange by any appropriate fasteners, such as by a rivet 91, screw, bolt, or the like. The mounting plate 38 carries thereon the first and second fiber chopper/entraining means 40, 42 respectively, as further explained below. The mounting plate 38 also has formed therein throughholes 43a and 43b for receiving therein means 44 for suspending the chute 20 above the preform mold 16 such as a suspender rod 46. The suspender rod 46, as shown, may be affixed at one end to the mounting plate 38 by a clamp 45 comprising a metal strap 47 surrounding the rod 46 and affixed to the mounting plate 38 by screws 49 held in the throughholes 43a, 43b. Alternatively, the rod may be attached to the chute 20 by other means such as a threaded receptacle (not shown) pivotally affixed to the mounting plate 38 and receiving a threaded end (not shown) of the rod 46 therein. The rod 46.

is attached, at the other end thereof, to the overhead support rack 60 by suitable means as known in the art. Provision is preferably made for suitable adjustability of the chute position in any such suspension arrangement.

The first and second fiber chopper/entraining means 40, 42 respectfully, are commercially available fiber strand choppers such as Model B-410 Choppers from Glass-Craft, Inc. of Indianapolis, Indiana. The fiber choppers 40, 42 are air-powered devices which chop, or cut, fiber strands 48, 52 into short lengths 74, 78 and blow these short lengths of fiber away from the chopper with a directed airstream 84, 86. Such choppers as are utilized with the present invention will preferably have separate motor speed and blower controls, as well as adjustable cutting lengths.

Separate choppers are needed for each fiber-type to adequately maintain consistent cutting results on the various types of fibers as may be used with the preform apparatus 10. Additional choppers may be supplied as needed for different fiber types or increased capacity.

The first fiber chopper/entraining means 40 is attached by conventional means, such as, through bolts (not shown) to the mounting plate 38 proximal to the chute first end 22 so as to be located upstream of the second fiber chopper 42 on a longitudinal airstream 71 supplied by the nozzle 24. A fibrous binder material strand 48, or strands, enter that side 50 of the first fiber chopper 40 distal to the chute 20 during operation of the preform manufacturing apparatus 10. The first chopper 40 is powered by directed air through an airline 41 attached to first chopper 40 at a nipple 41a. The binder material strand 48 currently used is a low molecular weight variety of KODEL (Trademark) polyester type fiber manufactured by Eastman Chemical Products, Inc. of Kingsport, Tennessee and Wellman, Inc. of Johnsonville, South Carolina. The binder

fiber strand currently used is supplied in the form of tow; i.e., a strand without definite twist collected in loose, rope-like form. It is envisioned that a variety of binder fiber strands may be suitably employed by those skilled in the art dependent upon the binder characteristics desired and the chopper/entraining means available to the artisan.

The second fiber chopper/entraining means 42 is attached to the mounting plate 38 by conventional means such as throughbolts (not shown) downstream of the first chopper 40 on the longitudinal airstream 71 of the nozzle 24. Glass fiber roving 52 of a known type enters that side 54 of the second fiber chopper 42 distal to the chute 20 during operation of the preform manufacture apparatus 10. The second chopper is powered by directed air through an air line 43 attached to the second chopper at a nipple 43a.

A mechanical baffle 56, or baffles, may be attached by known means such has pop rivets 57a, 57b or the like, onto or proximal to the chute 20 longitudinally downstream of the second chopper 42 to vary the fan, or dispersal pattern, of the fibers 72 exiting the chute second end 26. Alternatively or cooperatively with baffle 56, an oblique airstream 88 may be supplied through a second nozzle 58 to alter the dispersal pattern of the exiting fibers 72. The second nozzle 58 is preferably located longitudinally downstream of the second chopper 42 and will direct the airstream 88 obliquely downstream of the longitudinal axis of the chute 20. Alternatively, the enclosed cylindrical portion 30 of the chute 20 may be formed to provide dispersal, or fanning, means.

In use, as seen in Figures 1 and 2, the fiber delivery device 14 is suspended by a rod 46 from a support rack 60, or otherwise suitably affixed thereto. The delivery system 14 is placed such that the chute second end 26 is pointed toward the foraminous mold 16 when the mold

16 is in a position to have preform fibers 72 applied thereto.

A fibrous binder strand 48, is fed from its spool 62 through a strand guide 64 attached to the support rack 60. From there, the binder strand 48 is fed to the first chopper 40 which takes up the binder strand 48 as needed during operations. A strand of glass fiber roving 52 is likewise fed from its spool 64 into the second chopper 42. It will be appreciated that each chopper 40, 42 may handle a plurality of strands of preform fiber.

The preform manufacturing apparatus 10 is then activated so as to translate the mold 16 in the horizontal plane beneath the fiber delivery system 14.

In the preferred embodiment the fiber delivery system 14 is activated by a position indicator 66 read by a sensor unit 68 which, in turn communicates with a control unit 70 for the preform manufacturing apparatus 10. The air line 36 to the nozzle 24 is first activated to provide the longitudinal air stream 71 down the chute 20. The first chopper 40 is then activated. The first chopper 40 takes up the binder strand 48 and cuts it to the desired length. The desired length of cut is determined by the need to separate the binder fiber 48 completely into individual filaments and how the particular binder fiber being used is held together. For example, if the binder filaments 76 are formed into a strand by turning or crimping the filaments three times per inch, the chopper 40 will be set to cut the strand at one-third inch intervals. This length of cut ensures that no cut length 74 of binder fiber will have its filaments 76 held together by more than one turn or crimp. Thus, the binder filaments within each cut length 74 can be easily separated. Alternatively, untangled or loosely held strands of filaments may be cut to any desired length.

The first chopper 40, after cutting the binder

fiber strand 48 into cut lengths 74, entrains the cut lengths 74, by means of an airstream 84, transversely into chute 20 through side opening 28 and thereby into the longitudinal airstream 71. It will be appreciated that either chopper 40, 42 may entrain its cut fibers 74, 78 into the chute 20 without additional thrust from a chopper supplied airstream 84, 86 if such an arrangement is adequate for the size of chute being used.

As the cut lengths 74 of binder fiber impinge upon the longitudinal airstream the filaments 76 therein are blown apart from each other. At this point approximately ninety-five percent of the filaments are separated out from the cut lengths 74.

The second chopper 42 is activated an instant after the first chopper 40 to entrain cut bundles 78 of glass fiber from the glass fiber roving 52 into the chute 20. The length of the glass bundles 78 is largely determined by the physical properties desired in the preform. The glass bundles 78 have more mass than the cut binder lengths 74 and therefore will travel through the longitudinal airstream and rebound off the chute wall 32.

As seen in Figure 4, the glass bundles 78 will substantially retain their original physical form and will not be separated into individual filaments 80 by the longitudinal airstream or by contact with the chute wall 32. Mixing of the binder filaments 76 and the glass bundles 78 occurs in the glass-bundle rebound area 82 of the chute. Impingement of the glass bundles 78 on the binder filaments 76 will substantially complete the remaining five percent of binder filament 76 separation. The mixture of preform fibers 72 is approximately ninety-five percent structural to five percent binder although this ratio may be adjusted dependent upon the qualities of the preform fibers and the desired preform properties.

The preform fiber mixture is then directed out of the chute second end 26 and onto the foraminous mold 16. The resultant matrix of preform fiber will contain individual binder filaments 76 substantially surrounding and contacting the glass bundles 78 in an evenly distributed three dimensional matrix of randomly oriented preform fibers.

Upon heating, the binder filaments 76 will adhere to the glass bundles 78 and to each other thereby knitting together the entire structure and producing a set preform capable of further processing into a finished part. It will be appreciated that this dry matrix of preform fibers 72 will require substantially less heat to set than the known preforms using an aqueous binder. Thus, a savings in time and energy costs is obtained.

As seen in Figure 2, should the width of the preform mold require more than one fiber delivery device 14 for necessary fiber coverage, a plurality of fiber delivery devices 14 may easily be arranged over the mold 16 in a variety of arrays.

As graphically illustrated in Figure 5, without any baffling, the natural distribution of the preform fibers from the chute 20 onto the mold 16 is heavily center-weighted under the diameter of the chute. In other words, the amount of fiber deposited at, or beyond, the edges of the chute 20 drops off rapidly, as represented by the steep bell curves 90.

In order to alleviate the undesired areas of sparse fiber deposition on those parts of a mold which may lie beneath or beyond the edges of the chute 20, a mechanical baffle 56 or an oblique airstream 88, or both, are utilized as means for fanning the standard fiber distribution and thereby substantially evenly spreading the preform fibers 72 over the mold 16. Alternatively, the enclosed chute cylindrical portion 30 may be shaped to

provide the necessary mechanical baffling.

In use of the illustrated embodiment the stream of fibers emitted from the chute is compressed on each of two opposing sides by the mechanical baffle 56, and the oblique airstream 88 from the additional nozzle 58, respectively, to broaden the stream, thereby changing the distribution pattern from a circle to an ellipse as graphically represented by the flattened curves 92.

Care must be taken in the placement and operation of the additional fan elements 56, 58 so as to not separate or stratify the heavy glass bundles 78 and light individual binder filaments 76 from their well-mixed condition in the longitudinal airstream 71.

Thus it will be seen that the present invention provides a clean and efficient method of delivering fibers to a foraminous mold in a well distributed matrix of individual binder filaments and glass fiber bundles.

Having, thus, described the invention, what is claimed is:

CLAIMS

1. An apparatus for the delivery of fibers to a foraminous mold, comprising:

(a) a substantially tubular chute having:

(1) a first end having an opening for receiving an airstream,

(2) a second end having an opening for discharging preform fibers, and,

(3) an opening in the chute for admitting preform fibers into the chute;

(b) means for attaching a binder fiber chopper in proximity to the chute;

(c) means for attaching a structural fiber chopper in proximity to the chute; and,

(d) an air nozzle for directing an airstream through the chute in a direction from the first chute end to the second chute end.

2. The apparatus of Claim 1, further comprising:

a binder fiber chopper capable of receiving and cutting a strand of binder fiber, the binder fiber chopper being located in proximity to the chute.

3. The apparatus of Claim 2, further comprising:

a structural fiber chopper capable of receiving and cutting a strand of structural fiber, the structural fiber chopper being located in proximity to the chute.

4. The apparatus of Claim 2, further comprising:

means for entraining binder fibers into the chute.

5. The apparatus of Claim 2, further comprising:

means for entraining structural fibers into the chute.

6. The apparatus of Claim 1, further comprising means for fanning the fiber distribution from the chute.

7. The apparatus of Claim 6 wherein the fanning means comprises a second nozzle for dispersing an airstream obliquely to the longitudinal axis of the chute, the second

nozzle located in proximity to the chute.

8. The apparatus of Claim 6, wherein the fanning means comprises a mechanical baffle.

9. A method for applying fibers to preforms comprising the steps of:

(a) placing a chute over a foraminous mold;

(b) producing an airstream within the chute directed towards the foraminous mold;

(c) entraining binder fibers into the airstream;

causing the airstream to separate the binder fibers into individual binder filaments;

(d) entraining cut lengths of structural fibers into the airstream at a point in the chute downstream of the point where the binder fibers are entrained; and,

(e) directing the resultant mixture of binder filaments and structural fibers onto a foraminous mold.

10. The method of Claim 9 further comprising the steps of producing the binder fibers by cutting a strand of binder fibers before the entrainment of the binder fibers into the airstream.

11. The method of Claim 9 further comprising the steps of producing the structural fibers by cutting a strand of structural fiber before the entrainment of the structural fiber into the airstream.

12. The method of Claim 9, further comprising the step of,

fanning the dispersal pattern of the mixture of binder filaments and structural fibers before the mixture reaches the foraminous mold.

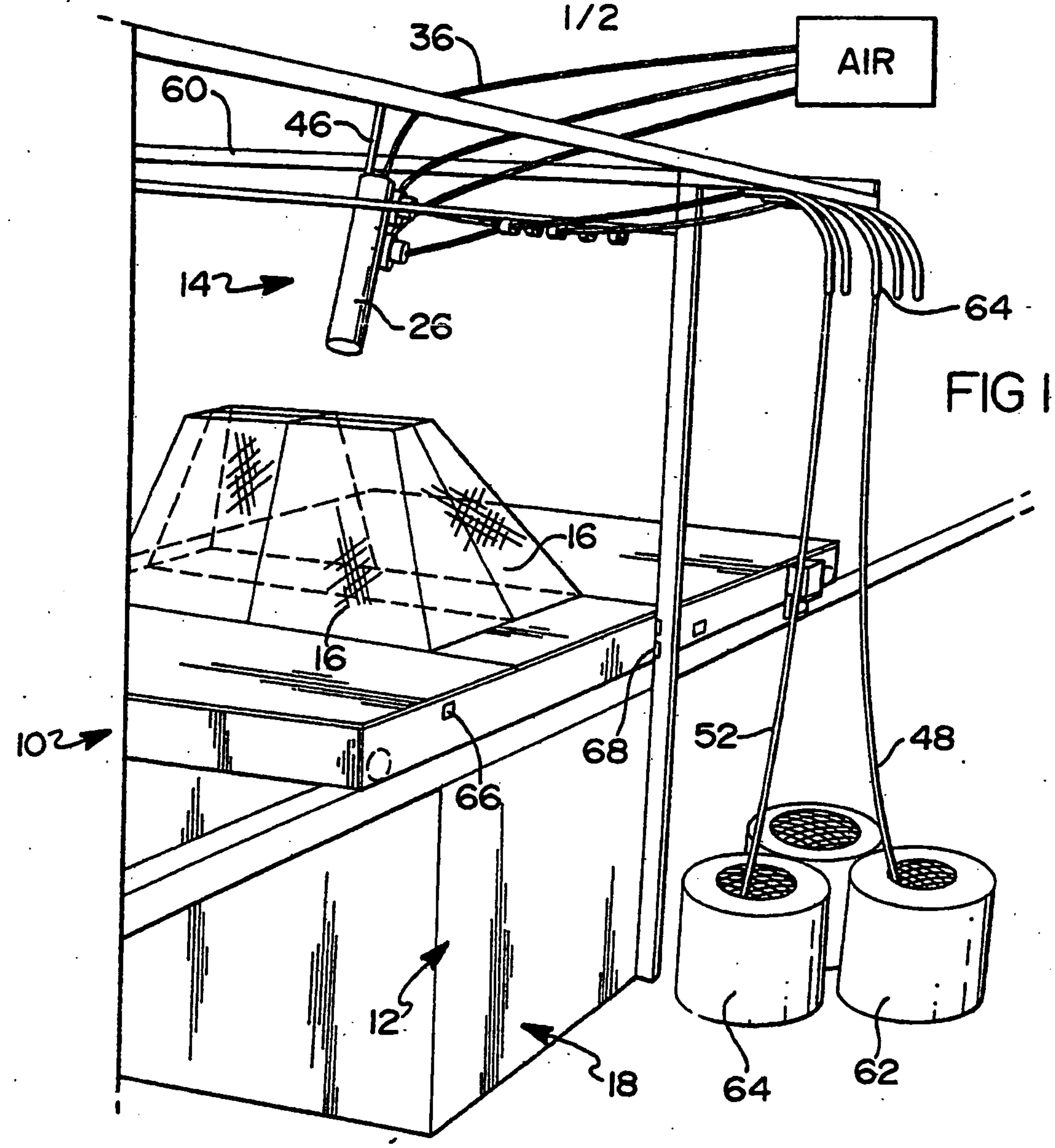
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FIG 1

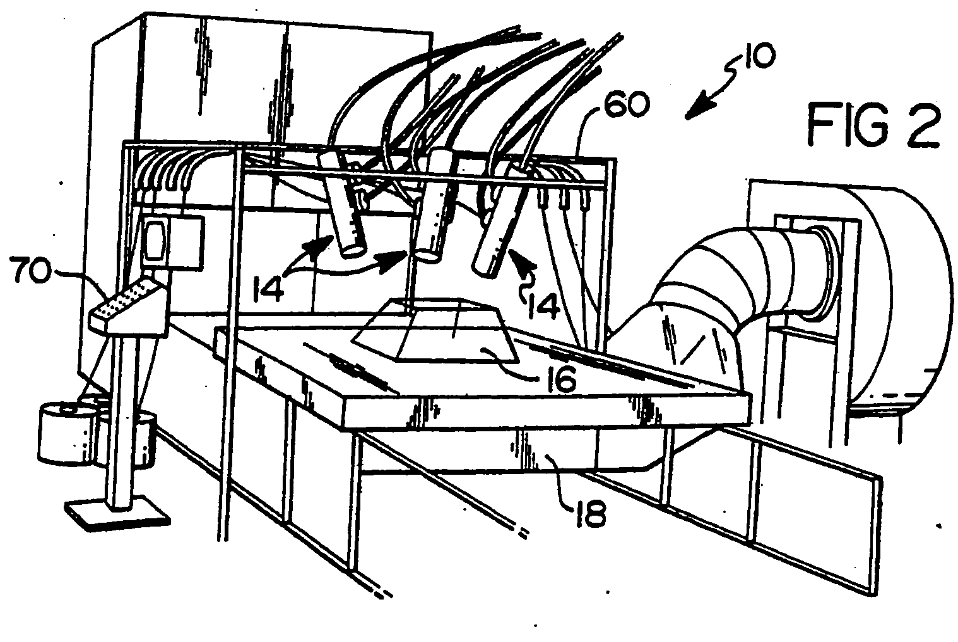
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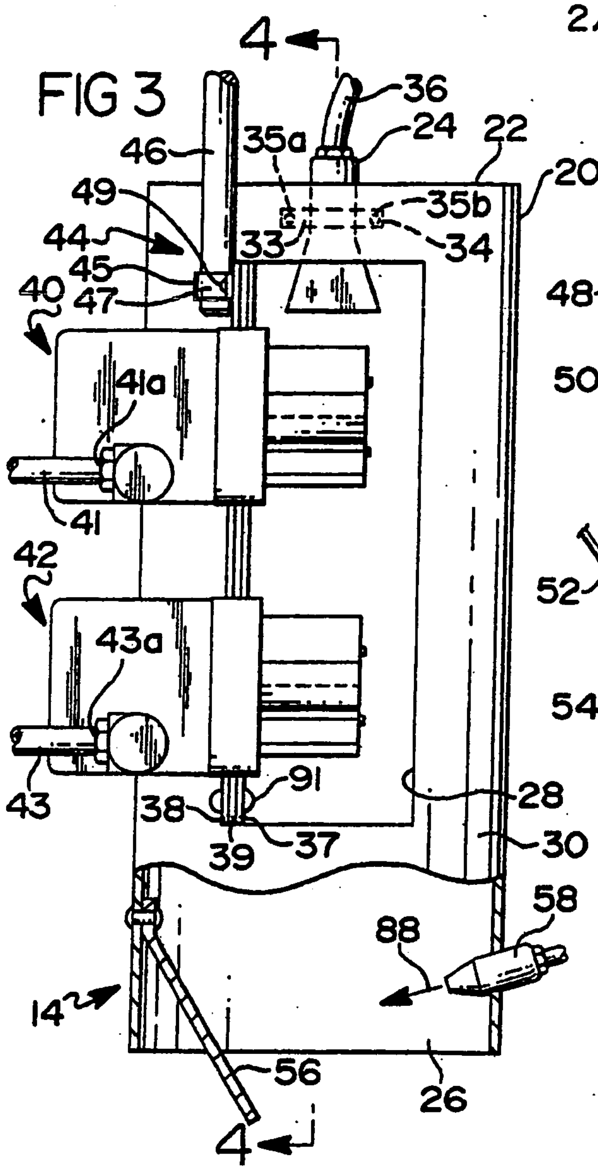
FIG 2

FIG 3



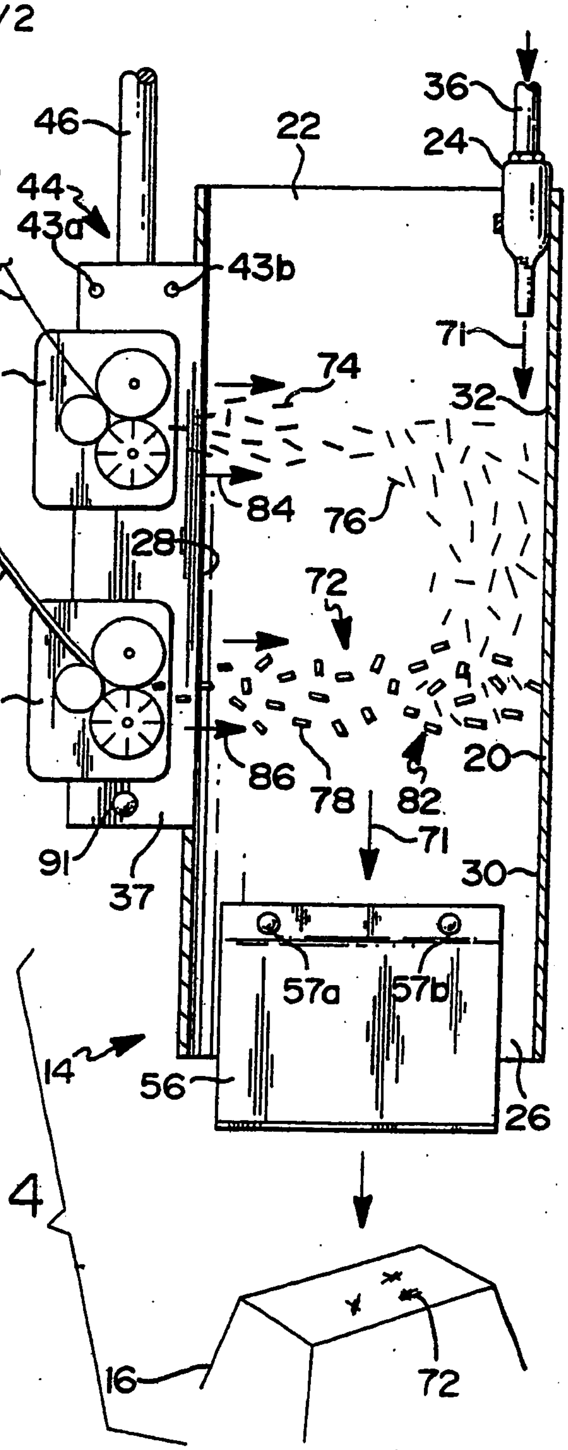


FIG 4

FIG 5

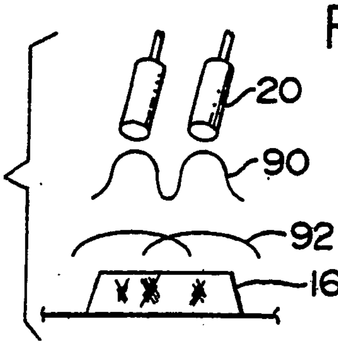
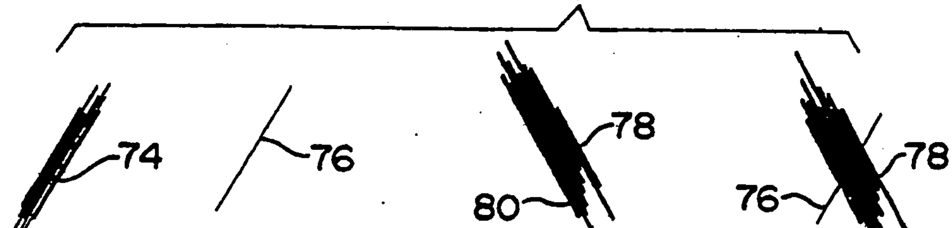


FIG 6



INTERNATIONAL SEARCH REPORT

International Application No PCT/US91/01182

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC
IPC(5): B27N 5/00
US CL : 264/115,517,121,122; 425/80.1,82.1

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
US	425/82.1,80.1,81.1,83.1; 264/517,518,115,121,122

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
Y	US, A, 2,702,261 (BACON) 15 February 1955 See entire document.	1-12
Y	US, A, 3,010,161 (DUVALL) 28 November 1961 See entire document.	1-12
Y	US, A, 3,834,869 (ANCELLE) 10 September 1974 See entire document.	1-12
Y	US, A, 4,701,294 (RADWANSKI) 20 October 1987 See entire document.	4,5,8
A	US, A, 3,328,383 (ROSCHER) 27 JUNE 1967.	
A	US, A, 3,963,392 (GOYAL) 15 June 1976.	
A	BE, A, 566,851 (RENAULT) 14 May 1958	
A	FR, A, 2.214.005 (JEANNEAU) 09 August 1974	

* Special categories of cited documents: [15]
"A" document defining the general state of the art which is not considered to be of particular relevance
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
02 MAY 1991	20 MAY 1991
International Searching Authority [1]	**Signature of Authorized Officer [20]**
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Form PCT/ISA/210 (second sheet) (May 1986)